

second detector 182 along a second detector image plane 184 to receive the 2R1T image plane 172 and the 2R defocused focus cell images 232. One implementation also uses an additional reflector 186 to redirect the 2R1T image plane 172 and the 2T defocused image plane 176. As illustrated in Figure 10, the 2R1T object plane 178 has a 2R1T object field depth 188 and the 2T defocused image plane 180 has a 2T defocused object field depth 190, which share a second object field depth overlap 192. The 2R defocused object field depth 166 and the 2R1T object field depth 188 also share a third object field depth overlap 194.

As shown, the defocus system 126 can be implemented as the negative lens 128. In other implementations, the defocus system 126 can be a positive lens element or a compound optical system configured to decollimate inputted collimated light. Implementations include lens elements being ground and polished or molded, being glass or plastic, being reflective or refractive, and having spherical or aspherical surfaces. Implementations using compound optical systems may include both transmissive and reflective optics. An exemplary compound optical system implementation of the defocus system 126 is illustrated in Figures 11 and 12 where the first reflected light 138, as collimated light, enters a first positive lens 194 and is brought to focus at an intermediate focal point 196. As shown in Figure 11, a focused lens spacing 198 between the intermediate focal point 196 and a second positive lens 200 is set to the focal length of the second positive lens such that a collimated light 202 leaves the defocus system 126.

The performance of the exemplary implementation illustrated in Figure 11 could be duplicated by any number of lens combinations conventionally known. In order to modify the optical power of the first reflected light 138, either optical power is added or subtracted from the first reflected light by the defocus system 126. As shown in Figure 12, negative optical power is introduced into the first reflected light 138 by shortening the intermediate focal point 196 to a defocused lens spacing 204 being less than the focal length of the second positive lens 200. The shorter length of the defocused lens spacing 204 results in a divergence of light exiting the second positive lens 200 of the defocus system 126 as defocused 1R light 148. If positive power is introduced to the first reflected

light 138, the length of the defocused lens spacing 204 is made greater than the focused lens spacing 198 resulting in a convergence of light exiting the second positive lens 200 of the defocus system 126.

5 An alternative implementation of the imaging system 100 uses a version of the object light 132 being linearly polarized having a first polarization state vector 206 oriented in the x-y plane, as illustrated in Figure 13. The collection lens 108, the beam splitter optical coating 112, and the first reflector 124 act upon the object light 132, the collected light 134, and the first reflected light 138, respectively, without affecting the orientation of the first polarization state vector 206. In this implementation, the imaging
10 system 100 uses a polarization beam splitter 208 having a polarization beam splitter optical coating 210 being oriented in the polarization beam splitter such that the first transmitted light 136, with its particularly oriented first polarization state vector 206, passes substantially completely through the polarization beam splitter 208 as the 2T1T light 138 due to the orientation of the first polarization state vector. After leaving the first reflector
15 124, the first reflected light 138 passes through an optical retardation plate 212 thereby altering the first polarization state vector 206 to a second polarization state vector 214 being oriented in the x-z plane, as illustrated in Figure 13. Subsequently, the defocused 1R light 148, having the second polarization state vector 214, is substantially completely reflected off of the polarization beam splitter 208 of the polarization beam splitter optical
20 coating 210 as the 2R defocused light due to the orientation of the second polarization state vector. As a result of the polarization effect associated with the polarization beam splitter 208, both the 2T1T light 138 and the 2R defocused light are substantially brighter compared to other implementations of the imaging system 100 not relying upon the polarization effect. When compared with other implementations, optical efficiency is
25 approximately doubled by utilizing the polarization effect although there is some absorption loss associated with the optical retardation plate 212.

An alternative implementation of the imaging system 100 uses a polarized and un-polarized versions of the object light 132. The polarized version of the object light 132 has a third polarization state vector 216 oriented in the y-z plane and approximately 45

degrees relative to both the y-axis and the z-axis, as illustrated in Figure 15. The collection lens 108 passes the object light 132 as the collected light 134 without affecting polarization. A polarization beam splitter 218 having a polarization beam splitter optical coating 220 receives both polarized and un-polarized versions of the collected light 134 and splits the collected light into a polarized version of first transmitted light 136 having the first polarization state vector 206 oriented along the y-axis plane and a polarized version of the first reflected light 138 having the second polarization state vector 214 oriented along the z-axis.

The first reflector 124, the and the second reflector 130 do not substantially alter the polarization of the first reflected light 138 with the second polarization state vector. The polarization beam splitter optical coating 210 of the polarization beam splitter 208 is oriented such that the first transmitted light 136 with the first polarization state vector 206 passes substantially completely through the polarization beam splitter optical coating of the polarization beam splitter as 2T1T light 138 also with the first polarization state vector and the defocused 1R light 148 with the second polarization state vector 214 is substantially completely reflected off of the polarization beam splitter optical coating of the polarization beam splitter as 2R defocused light also with the second polarization state vector. As a result, an approximate doubling of optical efficiency is achieved, as compared with other implementations, without additional expense and absorption loss associated with use of the optical retardation plate 212.

An implementation of the first detector 120, composed of picture elements such as detector pixels arranged in detector row 222 and detector columns 224, is illustrated in Figure 16. Typically, such an implementation of the first detector 120 would utilized time delay integration (TDI). Cells or other objects as the target object 102 are entrained in a fluid stream to be imaged on the first detector 120 as they flow in a fluid flow direction 226 through the flow cell cuvette 104. Sets of 2T1T focus cell images 228 in a 2T1T focus area 230 and 2R defocused focus cell images 232 in a 2R defocused focus area 234 are imaged on the first detector 120 along the detector columns 224. The 2T1T focus area 230 and the 2R defocused focus area 234 are spatially separated from one